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REPLY TO
ATTN OF:

SUBJECT: Conference paper on ozone-depleting substances (ODS) inventory volumes

TO: Web site users

The accompanying paper was developed from a draft report produced for the Office of Environmental Policy and Assistance (EH-41). It provides a summary of DOE's efforts to phase out dependence on ozone-depleting substances throughout its facilities. Information is provided from Departmental response to a request for a information on present and estimated future inventories of ODS, phase-out efforts, and practices.

Forty-four sites provided this specific information in late 1996 and early 1997. This paper provides an overview of the site activity and reported inventories.

Report on the Department of Energy's (DOE) Inventory and Phaseout of Ozone-Depleting Substances (ODS)

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Introduction

This paper was developed from a draft report produced for the Office of Environmental Policy and Assistance (EH-41). It provides a summary of DOE's efforts to phase out dependence on ozone-depleting substances throughout its facilities.

In November 1995, EH-41 (Office of Environmental Policy and Assistance) issued the document, *"Guidance on the DOE Facility Phaseout of Ozone-Depleting Substances,"* (DOE/EH-511). The guidance was developed to assist DOE user organizations in meeting the broad and specific requirements of a number of directives related to these substances, including E.O. 12843 (*Procurement Requirements and Policies for Federal Agencies for Ozone-Depleting Substances*). The guidance also requested departmental elements using ODSs to submit a report covering present and estimated future inventory volume; procurement needs for FY 1995, as well as, type and estimated ODS quantities needed for FY 1997 and FY 2000; a list of mission critical uses and estimated ODS inventory volumes for servicing these uses; and successful phase-out efforts and exemplary practices. Forty-four sites provided this specific information to EH- 412 in late 1996 and early 1997. This paper provides an overview of the site activity and reported inventories.

Definitions and Affected Substances

The following are the definitions used in the preparation of the DOE wide report.

<u>ODS</u>

Substances known to deplete the stratospheric ozone layer. ODSs are divided into class I and class II in the Clean Air Act of 1990. The most damaging substances are class I and include CFC-11, 12, 13, 113, 114, 115, MCF, CCl_4 and Halon 1211 and 1301.

<u>Chemical Names and Nomenclature</u>

In order to create a master inventory table it is necessary to establish a standardized naming system for the various ODS substances listed by each site. ODS substances used as refrigerants are generally referred to by a numbering system developed by the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) (see ASHRAE Standard 34-1992) and the International Organization for Standardization. Table 1 clarifies the naming system used and covers the substances actually reported by DOE sites.

Mission-Critical Uses
Those uses required to meet DOE missions for which there is no safe alternative chemicals or technologies that are commercially available.

Exemplary Practices
The “exemplary practices" are defined as those actions which go beyond the regulatory requirements placed on ODS phaseout and use. Examples of exemplary practices include proactive planning and implementation using innovative technologies to eliminate ODS use; implementing site policies on the use, procurement, and emissions of class I ODSs; and planning for the production phase out of class II substances.

Summary of Results
Phase-out efforts, are widespread across the DOE-complex and include recovery and recycling activities, substance substitution or elimination, expanded preventative maintenance programs, equipment upgrades and phaseout, revised procurement regulations and procedures, ODS management programs, revised operating practices, and distribution control. Past, the sites, along with discussions on recover/recycling equipment and mission-critical uses also provided current, and estimated future substance inventory volumes (table 1).

Based upon the information received from the sites, it is anticipated that DOE may reduce its total inventory volume of ozone-depleting substances during the 5-year period from 1995 to the year 2000 by approximately one-third. The actual **reduction in usage**, as opposed to total inventory volume, is expected to be even greater because unused inventory is often retained in storage and appears statistically as part of the total inventory volume. As substitutes for class I ozone-depleting substances become more readily available, it is reasonable to expect that usage and inventory volumes will continue to decrease in even greater numbers.

Overview of Application Specific Phaseout Activities
DOE primarily uses ozone-depleting substances for:
1) refrigeration and air conditioning, 2) fire suppression, 3) solvent cleaning/lubrication, and 4) laboratory research and testing. Each of these application areas will be discussed in the following sections. An overview is presented of each application’s reduction options, potential chemical substitutes, and ongoing or proposed site phase-out activities.

Air Conditioning
Refrigerants are working fluids (class I and class II) that are used in refrigeration, air conditioning, and heat pump applications. Cooling systems include air conditioners, process chillers, freezers,

refrigerators, drinking fountains, vending machines, cafeteria equipment, and laboratory equipment. Some special refrigeration applications are associated with the use of exotic materials, radioactive substances, and large-scale applications. This application, comprises approximately 70% of the total ODS inventory at DOE facilities. Reduced usage and phaseout programs include refrigerant recovery and recycling, conservation practices which eliminate unnecessary emissions of CFCs, and the use of EPA approved alternative substances.

Refrigerant can often be recovered from replaced, retrofitted, or retired equipment and effectively recycled onsite. Once recycled, the refrigerant can be added to the stored inventory, used to maintain operating equipment, or even placed in new equipment if appropriate. Proper recovery, recycling, and reclamation activities significantly reduce the release of ODSs to the atmosphere.

Proactive conservation practices include preventing leaks by increasing the level of periodic preventative maintenance including establishing leak checking protocols; installing high efficiency purge systems; using stationary receiver tanks; and eliminating all venting during servicing and/or repair through approved innovative techniques, practices, and procedures. Conservative maintenance procedures have also been implemented at several sites.

Alternative Chemical Substances for Refrigeration and Air Conditioning

Each alternative must be evaluated based on the site's specific usage. The EPA has established the Significant New Alternatives Policy (SNAP) Program to identify alternatives to ODSs for all applications and publishes a list of acceptable and unacceptable substitutes. Lists of substitutes can be obtained from the Stratospheric Protection Hotline at 1-800-296-1996, or over the Internet at the EPA site "http: //www.epa.gov/ozone/title6/snap/". ODS chemical substitute information can also be obtained from the DOE Office of Environmental Policy and Assistance website "http://tis-nt.eh.doe.gov/oepa/".

Specific Site Reduction Activities

The following discussion highlights phase-out activities occurring in refrigeration/air conditioning applications at various DOE facilities.

Substitution: Many sites report that they are actively substituting ODS class I and class II refrigerants with recommended acceptable substitutes as they become available. (LLNL)

Equipment Replacement: Whenever possible appliances are being replaced with non-ODS equipment. Many sites restrict the purchase of any new equipment that uses CFCs and only allow such purchases with special authorization. This phase-out activity occurs most often with small appliances such as refrigerators, ice machines, and water coolers. However, several sites reported replacing air-conditioning units and large chillers, some up to 900 tons, which used CFC-11, CFC-12, or HCFC-22 with equipment using HFC-134a or HCFC-123. Such replacements have resulted in the phase out of several thousands of pounds of class I substances

in favor of less ozone damaging refrigerants. (SRS, Pinellas, Fermi, NTS, WIPP, West Valley, Knolls, BPA, Morgantown)

Equipment Upgrades and Retrofits: The most common type of equipment upgrade mentioned is high-efficiency purge units and reseating pressure relief valves to minimize emissions. Sites also reported retrofitting chiller units in order to use alternative refrigerants such as HFC-134a. (Rocky Flats, SRS, Pittsburgh, ORNL)

Management Programs and Plans: Many sites have written management plans and established oversight committees to control the procurement, disbursement, use, maintenance practices, and phase-out of ODSs. These plans and committees are seen as playing critically positive roles in the phase-out effort for all ODS applications. The plans may be generic, application specific, or both. (Y-12, SRS, Fermi)

The sites and headquarters have devised many contracts and purchase agreements written specifically to meet the goals of E.O. 12843 and the Clean Air Act. One such example is from Western New York Nuclear Services where the site has a contract in place that requires its contractors to recover ODS from equipment prior to disposal and prohibits venting. Technician and equipment certifications, as required by the CAA, are also specified in the contract.

A Basic Ordering Agreement (BOA) for purchasing commercial centrifugal and rotary screw water-chilling packages in the 100 to 2,000 ton cooling capacity range has been put in place by DOE-HQ. By using generic chiller specifications and a streamlined procurement process significant savings in time and money should occur.

Fire Suppression

Traditionally a large portion of DOE's fire suppression equipment has used halons (Halon 1211 and Halon 1301). Starting in FY 91 DOE policy stated that no new halon fire suppression systems were to be proposed and no new halon portable fire extinguishers purchased. Existing halon systems were allowed to be maintained. Halon-1301 continues to be used throughout much of the DOE complex, particularly in areas where water cannot be used such as in locations that process or store fissile materials. Potential alternative systems include, monitored early warning fire detection systems, automatic wet pipe sprinklers, fast response sprinklers, pre-action sprinkler systems or a deluge water spray. Cost for replacement systems and effectiveness of alternative compounds continues to be major roadblocks to the replacement of halon by other suppression methods.

Alternative Chemical Substances for Fire Protection

Chemical substitutes need to cover the same applications that the halons have previously covered so effectively and include providing streaming agents and total flooding agents for both occupied and unoccupied spaces. There are several manufacturers of alternative chemicals and equipment for replacement systems (Table 2). There are also new standards being developed and published by the National Fire Protection Association (NFPA) for the use of many of the alternatives. Additionally, information is available from the Halon Alternatives Research Corporation at (703)

524-6636 or E-mail HARC@aol.com.

Halon recycling and conservation actions include eliminating training that discharges actual halons, expanded recovery and recycling efforts, decreased frequency of system tear down, alternative testing procedures and modified training practices.

Specific Site Reduction Activities

Conversion to Manual Systems and Substitution: Some sites have converted automatic actuating halon fire suppression systems to manually activated systems to help prevent inadvertent, unneeded discharge. Where possible, sites are substituting for halon with alternative agents in existing equipment. However, fire suppression equipment must often be replaced in order to use alternative substitutes. An example of a substitution success story occurred in 1995 when the SRS successfully replaced 2,600 pounds of Halon 1211 with alternative agents. (SRS, Fermi, Knolls, LLNL)

Equipment Replacement: Some sites are replacing many of their halon extinguishers with extinguishers containing either dry chemical, carbon dioxide (CO_2), or pressurized water units. Many sites noted that they are in the process attaining a complete phaseout of all portable fire extinguishers using halon. (Rocky Flats, WAPA, INEL, S&SCTA, WVDP)

Equipment Upgrades and Retrofits: When new facilities are built, new equipment installed, or significant equipment upgrades made halon alternative technologies such as FM-200, Water Mist, Intergin (argon/CO2), or quick response systems are installed. (Fermi, Knolls)

Equipment Removal: Halon systems are deactivated or removed as buildings are taken out of service. Duplicative systems are also being removed. For example, SRS reported removing multiple halon systems where other suppression systems already exist.(SRS, INEL, DOE/NV, YUCCA MTN., BPA)

Management Programs and Plans: Sites have written management plans and established committees to control the procurement, disbursement, use, maintenance practices, and phase-out of halon substances. For example, the Savannah River Site has authorized a specific “Halon Replacement Implementation Plan” (SRS).

Central Storage: Some sites noted the practice of shipping unwanted Halon 1301 to Savannah River, thus completely eliminating the inventory of halons at their facility. As another option, Hanford plans on transferring approximately 3,192 Kg of halon to a division of the Department of Defense for reuse. (WVDP, Hanford)

Solvent/ Lubricant

These applications are mostly class I substances used for cleaning and degreasing of electronic equipment, printed circuit board assemblies, mechanical equipment, and piping systems. Solvent substitutions for such chemicals as CFC-113 and methyl chloroform (1,1,1-trichloroethane) are highly process-dependent. Many of these cleaning applications are driven by various military specifications. Other uses include laboratory testing protocols that are driven by EPA such as EPA Analytical Laboratory Methods 418.1 and 8440 for past oil spill analyses or other regulatory requirements. The uses of these solvent ODSs are being reduced rapidly by replacement chemicals and newly developed technologies such as super-critical CO_2, aqueous cleaners, modern-covered and/or chilled solvent baths, special recovery equipment, and no clean manufacturing techniques.

Specific Site Reduction Activities

Alternative Procedures: The Rocky Mountain Region of the Western Area Power Administration (WAPA), is undertaking a phaseout of the use of Freon-113 for environmental analyses. EPA method 418.1 currently requires Freon-113 as a solvent. The Rocky Mountain Region is changing to a commercially available methanol-based test for field screening of total petroleum hydrocarbons to guide cleanup of past oil spills. The methanol-based method can be used as long as the results are verified by using the Freon-113 based method. In a similar effort, Pantex reported developing a field testing procedure that uses CFC-113 only in the final verification testing not the initial analysis. SRS has a new analytical method to replace CFC-113 use in laboratory applications. (WAPA, Pantex, SRS)

Substitution: LLNL reported that solvent wiping and parts degreasing operations have been drastically reduced by solvent substitution or the use of aqueous cleaners. Rocky Flats reported that the current use of chlorinated solvents has been nearly eliminated. As early as 1993, BNL began successfully substituting nonhazardous, biodegradable cleaner to replace CFC-113 and 1,1,1-trichloroethane and continue to replace other ODS solvent applications with non-ODS, nontoxic alternatives. At Mound, the Parts Machining Facility converted a CFC-113 application to d-limonene. At SRS, in machine and welding shops, CFC containing products were replaced with substitutes. (LLNL, Rocky Flats, Argonne, BNL, SRS)

Equipment Replacement and Removal: NTS replaced an MCF vapor degreaser with an Aqueous Cleaning System AQ-400/RU. Cleaning and degreasing operations have been reduced as operations are shutdown or retired.(Fermi, NTS, SRS).

Management Programs: Kansas City Plant has incorporated the goal of decreased chemical use into procurement planning. KCP's procurement system requires purchasers to justify the procurement of an ODS through an exemption request which encourages them to find alternatives. SLAC is currently forming an interdepartmental alternative solvents committee to eliminate the CFC 113 and MCF usage. LLNL is producing a formal publication of using solvent substitutes for cleaning.

Research/Other

Class I & II substances used in specialized laboratory activities represents a small portion of the ODS usage by DOE. Approximately 11,000 pounds of ODSs were reported as being used in 1995; this number is expected to be reduced to 2,000 pounds by the year 2000. Three chemicals, CFC-113, CFC-114 and 1,1,1-Trichloroethane compose the bulk of the ODS substances being used in this application.

The primary application for CFC-113 is laboratory analytical testing. This application has been mandated by EPA and is currently being studied by EPA to determine if different solvents can be used in the required protocols. The data indicates that the usage of CFC-113 in the research area will remain relatively constant through the year 2000. However, if there is a change in the EPA analytical procedure this area could probably be reduced significantly.

The usage of CFC-114 in research finds the majority (5,000 lbs.) of the use in a single experimental testing loop at the Knolls Site. The experimental testing loop is expected to be in operation through 1997.

The usage of 1,1,1-Trichloroethane (or MCF) is decreasing rapidly from the level of approximately 4000 lbs. in FY 95 to 1800 lbs. in FY 97 then to 475 lbs. by the fiscal year 2000. The main users are LBNL and the Nevada Operations Office, both of which are phasing out its use rapidly.

Specific Site Reduction Activities

Alternative Procedures: Changes in research applications come through changes in the process. The Knolls Site reduced their CFC-114 use by 30% by reducing the volume in the Testing Loop. Several sites mentioned efforts to develop a field testing procedure that does not use CFC-113, or other ODSs, in the initial analysis, but rather use it only for final verification testing. (LBNL, Pantex)

Substitution: Fermi Lab has an Illinois Environmental Protection Agency (IEPA) permit to operate two open top vapor degreasers, one utilizing CFC-113 and the other HCFC-141b. Operation of both degreasers has been suspended pending the selection of ozone safe alternative solvents. (Fermi)

Conclusions

Current and future substance substitutes play a major role in the phasing out of current ODSs. While alternative substances like HCFC-22, HCFC-123, help reduce emissions from class I substances, it is important that DOE facilities take a preemptive, long-range perspective when selecting which alternative substances will best fit each site's individual needs. The SNAP program has been developed to help avoid unhealthy tradeoffs. However, each site needs to address this issue in a responsible and forward thinking manner. It will do the site no good to implement use of a substance that will likely be prohibited, for whatever reason, in the near future. Additionally, if the alternative is to be phased out within the projected useful life of the equipment that must be systematically evaluated and planned for in the selection process.

DOE mission critical uses of ozone-depleting substances were reported by approximately one quarter of the sites. They identified the substance being used, estimated inventory requirements, application category, and the substance's functional use. Mission critical uses were reported for each of the four major DOE applications. While the use of halon agents for fire suppression were the most commonly sited mission critical uses, the use of CFC-12 and other refrigerants appear at several sites as essential for continued application in specialized work areas and laboratories.

The following table summarizes the reported inventory volumes received from forty-four DOE sites. The sites provided a compilation of information regarding their inventory statistics. Table 3, "Total Inventory of Ozone Depleting Substances" provides a break down of individual ODS compounds by application for the Fiscal years 1995, 1997 and 2000. Please note that there are three non-ODS compounds reported in the numbers. Because the sites choose to include these substances in their inventory numbers, they were carried over into the summary table as well. These non-ODS compounds show increases in total inventory volume over the five-year period. This is expected since they are substitutes for some of the ODS compounds. The totals in each block were taken directly from site reports and individual conversations with site contacts. With the exception of CFC-113 in 1997 solvent use and CFC-500 in 1997 in air conditioning/ refrigeration use the trends are all reasonable in that they do not increase except for the ODS substitutes/replacements. The trends for the ozone depleting substances are in the right direction. Additionally, the trends for the replacement/alternative substances indicate that changes are being made and the programs are actively working to find solutions.

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Table1- Standardized Naming System

Standard Name	Also Known As (AKA) (1)	Standard Name	Also Known As (AKA) (1)
Class I			
CFC-11	R-11; Freon® -11; CCl3F	Halon® 2402	Dibromotetrafluoroethane; C2Br2F4
CFC-12	R-12; Freon®-12; CCl2F2	CCl4	Carbon Tetracholoride
CFC-13	R-13; Freon® -13; chloro-trifluoromethane; CClF3	1,1,1-Tri	Trichloroethane; Methyl chloroform; MCF; C2H3Cl3,
CFC-13b1	R-13b1;Halon® -1301;	**Class II**	
	BFC-13b, 1CBrF3	HCFC-21	CHCl2F
CFC-113	R-113; Freon®-113; C2Cl3F3	HCFC-22	CFC-22; R-22; Freon®-22; CHClF2
CFC-114	R-114; Freon®-114; C2Cl2F4	HCFC-123	R-123; C2HCl2F3
CFC-115	R-115; Freon®-115; C2ClF5	HCFC-141b	C2H3Cl2F
Halon® 1211	Bromochlorodifluoromethane; CBrCClF2	HCFC-142b	C2H3ClF2
		HCFC-233	C3HCl4F3
Halon® 1301	Bromotrifluoromethane; CBrF3		

Other		
CFC-116	CF3CF3	Non-ODS
CFC-402b	R-402b; Suva® HP-81	Blend/Substitute/ODS
CFC-404a	R-404a; Suva® HP-62	Blend/Substitute/Non-ODS
CFC-500	R-500; Freon®-500	Blend/ODS
CFC-502	R-502; Freon®-502	Blend/ODS
CFC-503	R-503; Freon®-503	Blend/ODS
HFC-134a	R-134a; CH2FCF3	Substitute/Non-ODS
MP-39	R-401a	Blend/Substitute/ODS

(1)Some notations and site reports replaced "CFC" and "HCFC" with "R" designating the substance as a refrigerant or with "Freon®," which is a trade name.

Table 2 - Alternative Fire Suppression Agents1

Streaming Agents	Total Flooding Agents	
HCFC Blend B - Haltron I®	HFC-227ea FM 200®	HCFC Blend A NAF SIII
HCFC-123	C4F10 (CEA-410®)	Inert Gas/Powered Aerosol Blend(FS0140
HCFC Blend C -NAF P-III®	HFC-23 (FE13®)	Powdered Aerosol Blend A (SFE)
HCFC Blend D Blitz III®	IG-541 (INERGEN®)	Powdered Aerosol Blend C (FEAS)
HCFC-124	HFC-125 (FE-25®)	Gelled Halocarbon/Dry Chemical Suspension(PGA)
CF3I	HCFC-124	
Gelled Halocarbon/Dry Chemical Suspension (PGA)	IG-55® (Argonite)	CO2
	IG-10® (Argon)	Water Sprinklers
Water Mist (Potable or Natural Seawater)	C3F8 (CEA-308®)	Water Mist
Surfactant Blend A	HCFC- 22	
CO2 Dry Chemical, Water Foam	CF3I	
C6 F14 CEA-614®	HFC-134a	

1. The listed agents have various restrictions that are individual to the specific agent and any substitution would require thorough analysis by qualified fire professionals before final selection. Many of the fire suppression compounds are still being refined or are in the RDT&E stage. The rate of development of new agents makes it difficult to maintain a complete listing and this is not intended to provide all possible alternatives but to serve as a starting point.

Table 3. Total Inventory of Ozone Depleting Substances[1] - DOE Sites

Ozone Depleting Substance (lbs.)	Air Conditioning/Refrigerants			Fire Suppression			Solvents/Lubricants			Research/Other			Research		
	95	97	2000	95	97	2000	95	97	2000	95	97	2000	95	97	2000
CLASS I															
CFC-11	471,705	398,425	328,306	0	0	0	48,134	85	82	10	9	7	519,849	398,519	328,395
CFC-12	207,375	185,420	147,712	0	0	0	11,614	4	3	425	160	155	219,413	185,584	147,870
CFC-13	2,948	1,638	22,921	0	0	0	253	0	0	1	1	0	3,202	1,639	22,921
CFC-13b1	237	228	188	0	0	0	0	0	0	320	290	190	557	518	378
CFC-113	58,608	52,991	50,277	0	0	0	231,189	225,233	175,514	1,192	1,063	931	290,989	279,287	226,722
CFC-114	71,887	79,771	23,881	0	0	0	0	0	0	5,404	5,065	45	77,291	84,836	23,926
CFC-115	136	130	110	0	0	0	0	0	0	15	15	15	151	145	125
Halon 1211	0	0	0	125,765	125,176	98,931	0	0	0	0	0	0	125,765	125,176	98,931
Halon 1301	10	0	0	358,768	340,579	279,684	0	0	0	0	0	0	358,778	340,579	279,684
CCl_4	0	0	0	0	0	0	872	400	200	165	114	60	1,037	514	260
1,1,1-Tri	0	0	0	0	0	0	39,860	16,889	9,678	3,933	1,864	475	43,793	18,753	10,153
CLASS II															
HCFC-21	2	2	2	0	0	0	0	0	0	0	0	0	2	2	2
HCFC-22	917,073	543,615	508,522	0	0	0	98	49	49	56	56	56	917,227	543,720	508,627
HCFC-123	12,300	34,390	48,170	88	176	176	61	122	122	1	1	1	12,450	34,689	48,469
HCFC-141b	0	0	0	0	0	0	281	224	224	100	0	0	381	224	224
HCFC-142b	0	0	0	0	0	0	33	0	0	0	0	0	33	0	0
HCFC-233	0	0	0	0	0	0	50	0	0	0	0	0	50	0	0
OTHER															
CFC-116[1]	0	0	0	0	0	0	0	0	0	190	170	115	190	170	115
CFC-402b	6	6	6	0	0	0	0	0	0	0	0	0	6	6	6
CFC-404a[1]	59	86	116	0	0	0	0	0	0	0	0	0	59	86	116
CFC-500	73,523	80,653	65,113	0	0	0	0	0	0	0	0	0	73,523	80,653	65,113
CFC-502	12,232	9,972	6,129	0	0	0	0	0	0	0	0	0	12,232	9,972	6,129
CFC-503	2,370	1,755	1,678	0	0	0	0	0	0	0	0	0	2,370	1,755	1,678
HFC-134a[1]	16,663	34,309	57,406	0	0	0	0	0	0	0	0	0	16,663	34,309	57,406
MP-39	31	31	31	0	0	0	0	0	0	0	0	0	31	31	31
Misc. [2]	1,753	1,919	1,640	0	0	0	664	95	11	0	0	0	2,417	2,014	1,651
	1,848,918	1,425,340	1,262,208	484,621	465,931	378,791	333,108	243,101	185,883	11,812	8,808	2,050	2,678,459	2,143,180	1,828,932

[1] Non-DOS, included by some sites as additional background information. These substances were not consistently reported across the DOE complex.
[2] Miscellaneous substances include ODS inventory that was only listed by a single site.